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Original communication

An autopsy study of coronary atherosclerosis and its relation to anthropometric measurements/indices of overweight and obesity in men

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ABSTRACT

Atherosclerosis accounts for a large proportion of cardiovascular system associated morbidity and mortality. The present autopsy based study is aimed to study the correlation between coronary atherosclerosis and anthropometric measurements/indices of overweight and obesity such as; Waist Circumference (WC), Hip Circumference (HC), Body Mass Index (BMI), and Waist Hip Ratio (WHR) in men from southern India. The present research also analyses the correlation between anthropometric measurements/indices of overweight and obesity in men with number of coronaries affected with atherosclerosis in individuals. The study included 50 autopsies conducted in the Government District Wenlock Hospital, Mangalore during March and September 2008. The heart was dissected following standard autopsy protocol and a 5 cm section of the right coronary artery (RCA) in the atrio-ventricular groove from its origin, a 5 cm segment of the left anterior descending artery (LADA) distal to the origin of the circumflex artery, but including the region of origin of the circumflex branch and left coronary artery (LCA) from its origin till the circumflex branch were excised, dissected out, fixed in 10% formalin, marked for identification and sent for histopathological analysis. The study shows a positive correlation of WC and WHR with atherosclerotic changes in the RCA. The number of arteries affected with atherosclerosis is found to be well correlated with WC, BMI and WHR. The study confirms an association between anthropometric measurements/indices of obesity, grade of atherosclerosis in the RCA and the number of arteries affected with atherosclerosis. Anthropometric measurements/indices of obesity can be an effective means to identify high risk cases of atherosclerosis at an early stage that can be effective in reducing the associated cardiac morbidity and mortality.

1. Introduction

Atherosclerosis is a chronic degenerative condition of arteries responsible for significant cardiovascular morbidity and mortality worldwide. In the Indian subcontinent it is reported to be responsible for more than 25% of deaths.[1] Atherosclerosis can result in complications like myocardial infarction, stroke, embolization, ulceration and thrombosis which cause considerable morbidity and mortality, thus affecting the lifespan and the quality of life of a number of individuals. Abdominal obesity, independent of overall obesity has been related to atherosclerosis.[2,3] Anthropometric measurements and indices of obesity like body mass index (BMI), waist circumference (WC), and the waist hip ratio (WHR) have been related to the degree of atherosclerosis and coronary artery diseases in earlier studies.[4–7]

Correlation between grade of atherosclerosis, coronary heart diseases and anthropometrical measurements is studied for long. It has been suggested that while in living subjects, it would be expensive, difficult and even harmful to subject them to CT scans and other investigations and procedures involving contrast media to study mild atherosclerosis, no such harm is possible in study of autopsy cases.[8] This autopsy based study is aimed to correlate the anthropometric measurements and indices of obesity such as waist circumference (WC), hip circumference (HC), body mass index (BMI) and waist hip ratio (WHR) with the degree of atherosclerosis in the right coronary artery (RCA), main branch of the left coronary artery (LCA) and the left anterior descending artery (LADA) in

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Indian men. The study also analyze the correlation of the anthropometric measurements and indices of obesity with the number of coronaries affected with atherosclerosis in an individual.

2. Materials and methods

This prospective autopsy based study was conducted in the Department of Forensic Medicine, Kasturba Medical College (KMC), Mangalore. A prior approval was obtained from the Institutional Ethics committee. Informed Consent was taken from the relatives of the deceased before taking various body measurements and preserving samples (sections of coronary arteries) for histopathological examination. Fifty male autopsies conducted at the mortuary of District Government Wenlock Hospital, Mangalore during March and September, 2008 were included in the study. Anthropometric measurements were taken in the Government District Wenlock Hospital (GDWH) mortuary and histological analysis to grade the degree of atherosclerosis in coronary arteries was conducted at the Department of Pathology, KMC, Mangalore. Putrefied and decomposed bodies, mutilated bodies and fragmentary remains, bodies with congenital and acquired skeletal deformities affecting the stature and cases where death occurred due to burns or a prolonged illness were excluded from the study. The autopsied cases included in the study were aged between 16 and 75 years. Age distribution of the cases is shown in Fig. 1. All the cases included in the study were autopsied within 48 h of death except for a case where post-mortem interval was 54 h. The mean post-mortem interval in the cases included in the study varied between 3 h and 54 h, average post-mortem interval being 16.15 h.

2.1. Anthropometric measurements

Following anthropometric measurements were taken by a single investigator (DSP) before autopsy.

2.2. Body weight

The body weight was measured to the nearest kilogram using the cadaveric weighing machine.

2.3. Body length

The length of the cadaver was measured from the vertex of the cranium to the base of the heel to the nearest centimeter, with the cadaver in supine position. One cardboard sheet was placed at the head end of body (vertex) and another at the foot end (heel). The distance between these two flat surfaces was taken as the length of the cadaver.

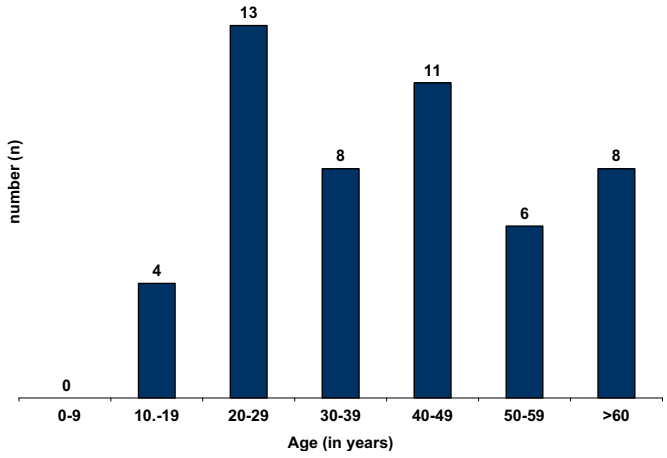

Fig. 1. Age distribution of the study sample.

2.4. Body mass index (BMI)

BMI was calculated as body weight (kg)/square of body length (m^2).[5]

2.5. Waist circumference (WC)

Waist circumference was measured to the nearest 0.5 cm using a measuring tape, at the level of the umbilicus, with the cadaver in a supine position.[9]

2.6. Hip circumference (HC)

Hip circumference was measured to the nearest 0.5 cm, using a measuring tape at the level of the greater trochanter, with the cadaver in a supine position.[9]

2.7. Waist hip ratio (WHR)

Waist to hip ratio was calculated as WC/HC.[9]

3. Preparation of the coronary arteries

The heart was dissected following standard autopsy protocol at autopsy. A 5 cm section of the right coronary artery (RCA) in the atrio-ventricular groove from its origin, a 5 cm segment of the left anterior descending artery (LADA) distal to the origin of the circumflex artery, but including the region of origin of the circumflex branch and left coronary artery (LCA) from its origin till the circumflex branch were excised and dissected out (Fig. 2). All the sections of coronary arteries from each case were fixed in 10% formalin, marked for identification and sent for histopathological analysis. Paraffin sections were made and the sections stained using Hematoxylin and Eosin (H & E) dyes. Thus, sections from a total of 150 arteries were examined for the degree of atherosclerosis in 50 individuals. The histopathological analysis of the sections and the grading of the atherosclerosis in the arteries were done by a single pathologist (MRP) who was blinded to the anthropometric measurements. The grading of atherosclerosis was done according to criteria suggested by the American Heart Association:

Grade 0: Sections showing normal histology or adaptive thickening without macrophages or foam cells.
Grade1: Presence of isolated macrophages and foam cells.
Grade 2: Mainly intracellular lipid accumulation.
Grade3: Grade 2 lesions along with small extracellular lipid pools.
Grade 4: Grade 2 changes along with a core of extracellular lipid.
Grade 5: Lipid core and fibrotic layer or multiple lipid cores and fibrotic lipid layers; mainly calcific or fibrotic.
Grade 6: Surface defect, hematoma, hemorrhages or thrombus formation.

The degree of atherosclerosis was classified as unremarkable (Grade 0), Mild (Grade 1–2), Moderate (Grade 3–4), and Severe (Grade 5–6). Grades of atherosclerosis as observed in our study cases are shown in Fig. 3.

The data was analyzed using SPSS (Statistical Package for Social Services) programme, version 11.0. Each anthropometric measurement and the derived index was classified into groups and

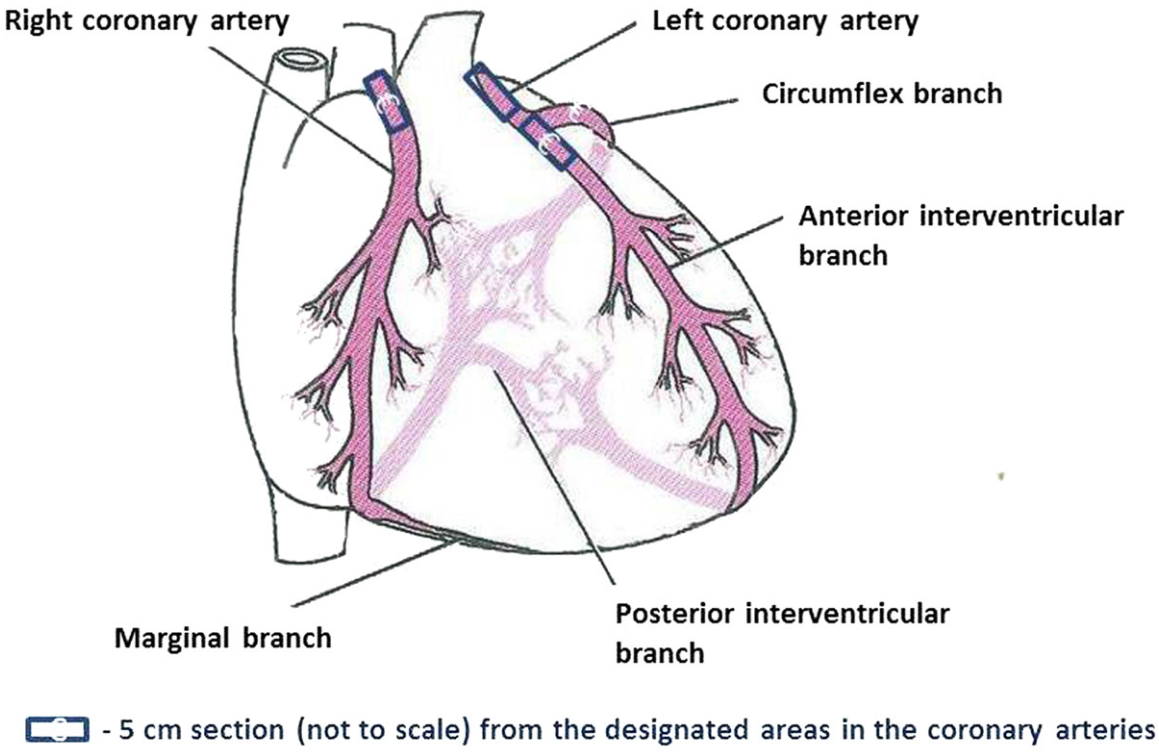

Fig. 2. Site of coronary arteries from where the sections were taken.

further analyzed in relation to degree of atherosclerosis and number of arteries involved in each case. While comparing the mean anthropometric measurements and indices of obesity for the grades of atherosclerosis and number of arteries affected with atherosclerosis, a non-parametric Kruskal–Wallis Test (K–W) was performed. The K–W value (*H*-value) of less than 0.05 was considered to be significant.

4. Results

Mean age of the study sample was 40.8 ± 16.7 years. Descriptive summary for the anthropometric measurements and the derived indices of obesity and overweight are shown in Table 1. All the anthropometric measurements and the derived indices were found to be significantly correlated to each other except for the age, that is

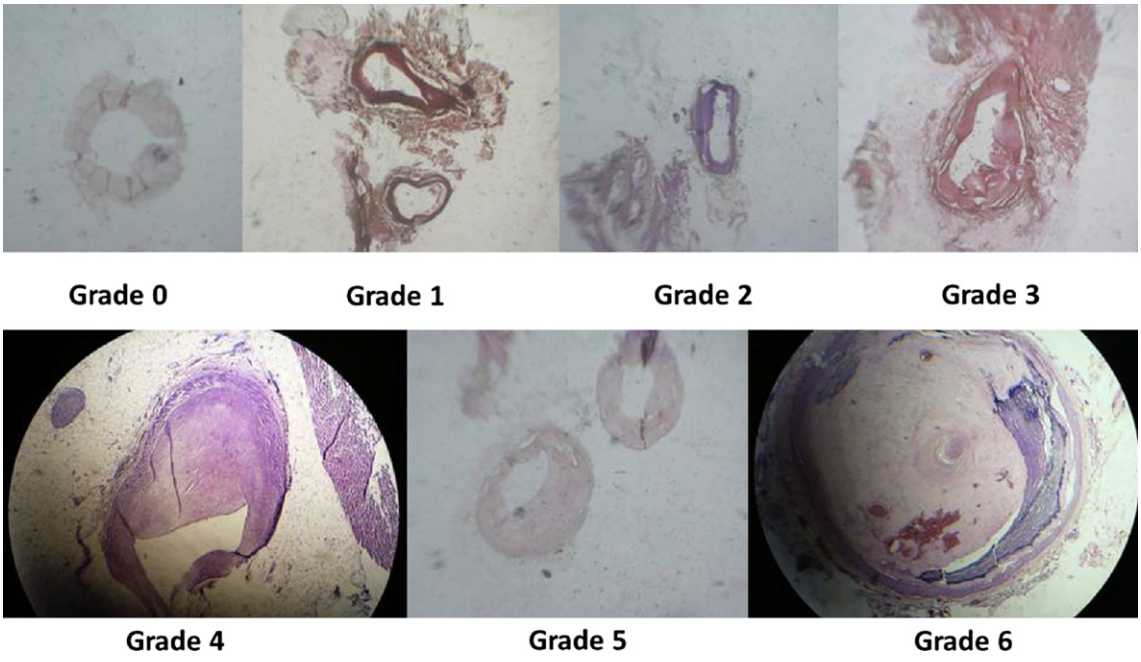

Fig. 3. Grades of atherosclerosis.

Table 1
Descriptive statistics for the anthropometric measurements.

	Age	Height (cm)	Weight (kg)	WC	HC	BMI	WHR
Mean	40.8	165	52.8	70.8	81.6	19.5	0.86
SD	16.7	5.9	8.4	9.1	6.9	3.4	0.05
Minimum	16.0	151	39.0	55.5	66.0	13.0	0.74
Maximum	75.0	179	72.0	94.0	97.0	30.8	1.06

WC – Waist Circumference (cm), HC – Hip Circumference (cm), BMI – Body Mass Index (kg/m^2),WHR – Waist Hip Ratio, S.D. – Standard Deviation.

found to have a significant correlation only with the WHR. Sections of a total of 150 arteries from 50 individuals were examined for the degree of atherosclerosis. Majority of the coronaries were unremarkable (n = 83, 55.3%). Mild atherosclerosis was observed in 15.3% (n = 23), moderate atherosclerosis in 16.7% (n = 25) and severe atherosclerosis was observed in 12.7% (n = 19) of the total coronaries examined (Fig. 4). Grade and severity of atherosclerosis in individual arteries is shown in Table 2. Severe degree of atherosclerosis was observed in LADA in 18%, LCA in 12% cases and RCA in 8% cases. Mean grade of atherosclerosis was found to be maximum for LADA followed by LCA and RCA. However, the difference was not statistically significant (p = 0.63). Complicated grade 6 lesions were reported only in the left anterior descending artery (n = 2). The age was not found to be significantly related to the degree of coronary atherosclerosis in any of the three arteries.

Descriptive statistics for the anthropometric measurements and the derived indices for individual arteries according to their grade of atherosclerosis are shown in Table 3. It is observed that the grade of atherosclerosis in RCA is significantly related to the WC and WHR. For other arteries no significant relation was observed between grade of atherosclerosis and anthropometric measurements/derived indices. Mean grade of atherosclerosis in each coronary arteries for the classification groups of anthropometric measurements and the derived indices are shown in Table 4. A significant relation was observed between grade of atherosclerosis in RCA and WC (H = 0.05) and WHR (H = 0.04), and between grade of atherosclerosis in LADA and HC (H = 0.02). With regard to number of arteries affected with atherosclerosis in an individual,

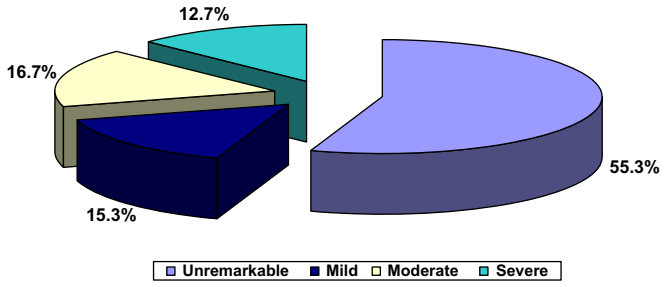

Fig. 4. Degree of atherosclerosis in coronary arteries (n = 150).

Table 2
Degree of atherosclerosis in the coronary arteries.

Degree of AS	RCA (n = 50) n (%)	LCA (n = 50) n (%)	LADA (n = 50) n (%)
Grade 0 (Unremarkable)	30 (60)	27 (54)	26 (52)
Grade 1–2 (Mild)	08 (16)	06 (12)	09 (18)
Grade 3–4 (Moderate)	08 (16)	11 (22)	06 (12)
Grade 5–6 (Severe)	04 (08)	06 (12)	09 (18)
Mean grade of AS[a]	1.22 ± 1.74	1.54 ± 1.94	1.64 ± 2.08

AS – Atherosclerosis, RCA – Right Coronary Artery, LCA – Left Coronary Artery, LADA – Left Anterior Descending Coronary Artery.
[a] p value > 0.05.

single artery was affected in 18% (n = 9), two arteries in 22% (n = 11) and all three in 24% (n = 12) of the cases (Fig. 5). Among the cases of single artery involvement, LADA was involved in 4, RCA in 3 and LCA in 2 cases. Among the cases where two arteries were involved, LCA was most commonly involved (n = 9), followed by LADA (n = 8) and RCA (n = 5). A combination of LCA and LADA involvement was seen in majority (55%) of the cases of double artery involvement. A significant relation is observed between the number of arteries involved and classification groups of WC, BMI, and WHR (Table 5). HC did not show any correlation with number of arteries involved.

5. Discussion

According to WHO, Waist Circumference along with the Waist Hip Ratio, is an approximate indicator of intra-abdominal fat mass and total body fat.[10] Central or Visceral obesity in which the fat accumulates in the trunk and in the abdominal cavity, in the mesentry and around the viscera is associated with a much higher risk for cardiovascular disease than just excess accumulation of fat in the subcutaneous tissue. Thus the increased amount of body fat would have played an important role in the genesis and the progression of atherosclerosis. This obesity results in endothelial dysfunction which initiates the process of atherosclerosis which is accelerated by the interaction of the lipid with macrophages and lymphocytes.[11] In the present study, Waist Circumference and the Waist Hip Ratio showed a significant correlation with atherosclerosis in the Right Coronary Artery. A study by Alexander shows a strong association between coronary heart disease and central obesity.[12] In an angiographic study, clinically significant coronary narrowing has been associated with obesity.[13] Earlier studies have shown a positive correlation of Waist Circumference and the Waist Hip Ratio with myocardial infarction, stroke and death.[14,15] Thus, obesity contributes to cardiovascular mortality via increased atherosclerotic burden.

According to McGill et al., increased BMI is directly related to high levels of LDL (p = 0.0001), a known risk factor for atherosclerosis and inversely related to HDL levels (p = 0.0577).[5] Another study by Larsson et al. showed that individuals with low Body Mass Index and a high Waist to Hip Ratio were at a high risk of death.[16] Our study did not show any significant relation between BMI and grades of atherosclerosis in the coronaries. In a study by Zamboni

Table 3
Descriptive statistics: anthropometric measurements in arteries according to the degree of atherosclerosis.

Artery	Grade	WC Mean (SD)	HC Mean (SD)	BMI Mean (SD)	WHR Mean (SD)
RCA	0 (n = 30)	67.2 (7.2)	79.8 (6.4)	18.5 (2.7)	0.84 (0.04)
	1 to 2 (n = 08)	74.4 (9.9)	83.7 (7.9)	21.3 (3.1)	0.89 (0.04)
	3 to 4 (n = 08)	76.9 (8.5)	85.8 (7.6)	20.3 (3.9)	0.89 (0.05)
	5 to 6 (n = 04)	77.9 (11.3)	83.1 (4.8)	21.8 (6.0)	0.93 (0.08)
	H-value	0.044[a]	0.349	0.154	0.025[a]
LCA	0 (n = 27)	68.7 (7.4)	80.7 (5.9)	18.9 (2.7)	0.85 (0.05)
	1 to 2 (n = 06)	69.9 (13.1)	81.2 (10.1)	19.8 (3.5)	0.86 (0.06)
	3 to 4 (n = 11)	75.6 (11.7)	84.3 (9.1)	21.3 (4.9)	0.89 (0.07)
	5 to 6 (n = 06)	71.9 (3.2)	81.5 (3.1)	18.7 (1.9)	0.88 (0.04)
	H-value	0.839	0.897	0.625	0.823
LADA	0 (n = 26)	69.4 (7.5)	81.5 (6.0)	19.1 (2.8)	0.85 (0.05)
	1 to 2 (n = 09)	69.4 (12.5)	80.7 (10.8)	19.2 (3.3)	0.86 (0.05)
	3 to 4 (n = 06)	71.5 (9.2)	82.0 (8.1)	19.7 (3.0)	0.87 (0.04)
	5 to 6 (n = 09)	75.5 (9.5)	82.9 (4.9)	20.9 (5.1)	0.91 (0.07)
	H-value	0.513	0.765	0.834	0.317

RCA – Right Coronary Artery, LCA – Left Coronary Artery, LADA – Left Anterior Descending Coronary Artery, WC – Waist Circumference (cm), HC – Hip Circumference (cm), BMI – Body Mass Index (kg/m^2), WHR – Waist Hip Ratio, S.D. – Standard Deviation.
[a] H-value < 0.05.

Table 4
Mean grade of atherosclerosis in relation to different anthropometric variables/indices.

Artery	Classification in groups				
WC	<60 ($n = 4$)	60–70 ($n = 25$)	70–80 ($n = 12$)	80–90 ($n = 6$)	>90 ($n = 3$)
RCA	0.25	0.56	2.17	2.00	2.67
LCA	1.75	0.96	2.17	1.67	2.33
LADA	2.00	1.04	2.42	1.83	2.67
HC	60–70 ($n = 1$)	70–80 ($n = 24$)	80–90 ($n = 19$)	>90 ($n = 6$)	
RCA	0.0	0.71	1.79	1.67	
LCA	3.0	0.88	2.37	1.33	
LADA	2.0	1.13	2.42	1.17	
BMI	<18.5 ($n = 21$)	18.5–25 ($n = 26$)	25–30 ($n = 2$)	>30 ($n = 1$)	
RCA	1.05	1.08	3.0	5.0	
LCA	1.38	1.54	2.0	4.0	
LADA	1.52	1.50	2.5	6.0	
WHR	0.6–0.8 ($n = 4$)	0.8–0.9 ($n = 38$)	0.9–1.0 ($n = 7$)	>1.0 ($n = 1$)	
RCA	0.0	1.08	2.4	5.0	
LCA	0.5	1.39	2.6	4.0	
LADA	1.0	1.39	2.7	6.0	

RCA – Right Coronary Artery, LCA – Left Coronary Artery, LADA – Left Anterior Descending Coronary Artery, WC – Waist Circumference (cm), HC – Hip Circumference (cm), BMI – Body Mass Index (kg/m^2), WHR – Waist Hip Ratio.

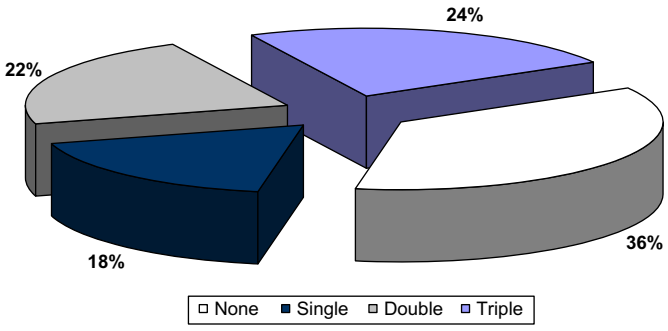

Fig. 5. Arteries affected in the study sample.

et al., there was lack of correlation between body mass index, subcutaneous adipose tissue area and angiographically demonstrated coronary artery disease.[13] Our findings support this view on lack of correlation of BMI with atherosclerosis. According to present study, Body Mass Index cannot be used independently to predict the grade of atherosclerosis of the coronary arteries.

Mean grade of atherosclerosis was maximum for LADA followed by LCA and RCA. Increased frequency of severe degree of atherosclerosis in LADA followed by LCA and RCA in the study sample is suggestive of an increased predisposition of left anterior descending artery and the left coronary artery to atherosclerosis. In cases of double artery involvement, a combination of LCA and LADA involvement was observed in majority of the cases which further strengthens our view on the increased predisposition of left coronaries to atherosclerosis. All the three arteries were affected with atherosclerosis in 24% cases followed by double artery involvement (22%) and single artery involvement in 18% cases. The findings suggest an increased frequency of triple artery involvement than double and single artery involvement. A significant correlation is observed between the number of arteries involved and WC, BMI, and WHR. Thus, these parameters may be the indicators of number of arteries possibly affected with atherosclerosis. To the best of our knowledge, none of the earlier studies have discussed

Table 5
Arteries involved in relation to different anthropometric variables/indices.

Arteries involved	Classification groups				
WC[a]	<60 ($n = 4$)	60–70 ($n = 25$)	70–80 ($n = 12$)	80–90 ($n = 6$)	>90 ($n = 3$)
None	00 (–)	15 (60.0)	03 (25.0)	00 (–)	00 (–)
Single	00 (–)	04 (16.0)	02 (16.7)	02 (33.3)	01 (33.3)
Double	03 (75.0)	04 (16.0)	02 (16.7)	01 (16.7)	01 (33.3)
Triple	01 (25.0)	02 (8.0)	05 (41.7)	03 (50.0)	01 (33.3)
HC	60–70 ($n = 1$)	70–80 ($n = 24$)	80–90 ($n = 19$)	>90 ($n = 6$)	
None	00 (–)	12 (50.0)	06 (31.6)	00 (–)	
Single	00 (–)	04 (16.7)	02 (10.5)	03 (50.0)	
Double	01 (100.0)	05 (20.8)	03 (15.8)	02 (33.3)	
Triple	00 (–)	03 (12.5)	08 (42.1)	01 (16.7)	
BMI[a]	<18.5 ($n = 21$)	18.5–25 ($n = 26$)	25–30 ($n = 2$)	>30 ($n = 1$)	
None	11 (52.4)	07 (26.9)	00 (–)	00 (–)	
Single	01 (4.8)	07 (26.9)	01 (50.0)	00 (–)	
Double	04 (19.0)	07 (26.9)	00 (–)	00 (–)	
Triple	05 (23.8)	05 (19.3)	01 (50.0)	01 (100.0)	
WHR[a]	0.6–0.8 ($n = 4$)	0.8–0.9 ($n = 38$)	0.9–1.0 ($n = 7$)	>1.0 ($n = 1$)	
None	03 (75.0)	15 (39.5)	00 (–)	00 (–)	
Single	00 (–)	07 (18.4)	02 (28.6)	00 (–)	
Double	01 (25.0)	09 (23.7)	01 (14.3)	00 (–)	
Triple	00 (–)	07 (18.4)	04 (57.1)	01 (100.0)	

WC – Waist Circumference (cm), HC – Hip Circumference (cm), BMI – Body Mass Index (kg/m^2), WHR – Waist Hip Ratio, n – number.
Values in parentheses denote percentage.
[a] H-value < 0.05.

anthropometric measurements and the derived indices in relation to number of arteries involved and on the comparative predisposition of arteries to atherosclerosis. Hence, our findings on these aspects cannot be compared per se and these findings need to be confirmed on a larger sample.

6. Conclusions

The study shows a positive correlation of WC and WHR with atherosclerotic changes in the RCA. The number of arteries affected with atherosclerosis is found to be well correlated with WC, BMI and WHR. The study confirms an association between anthropometric measurements/indices of obesity, grade of atherosclerosis in the RCA and the number of arteries affected with atherosclerosis. Age was not found to have any significant association with coronary atherosclerosis. A word of caution though is that the findings of the study should not be generalized to living populations per se for the reason that post-mortem alterations in length and weight of the body are known to occur. Moreover, possibility of contact flattening occurring as a post-mortem phenomenon affecting the Hip Circumference measurements exists.

Anthropometric measurements/indices of obesity can be an effective means to identify high risk cases of atherosclerosis at an early stage that can be effective in reducing the associated cardiac morbidity and mortality. A person with anthropometric measurements suggestive of mild atherosclerosis (Grade 1 and 2) can be advised to modify his lifestyle, along with decreasing his exposure to the other risk factors. Those with measurements suggestive of higher degree of atherosclerosis can be subjected to confirmatory procedures in order to start effective treatment.

Limitations in the study exist with regard to a small sample size and limited statistical analysis. Limitations regarding small sample size are primarily owed to the time bound nature of research project supported by the Indian Council of Medical Research (ICMR). Future research on larger samples with a consideration of intra and inter observer bias during anthropometric measurements as well as histopathological examination is suggested to confirm the findings of our study. It is proposed to study the clinical correlates and additional pathological findings such as heart weight, myocardial fibrosis, and associated risk factors associated with atherosclerosis in the future studies.

Conflict of interest

None to declare.

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Ethical approval

An approval was obtained from the Institutional Ethics Committee before taking up the research work.

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